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Direct Three-Dimensional Inversion of Ptychographic X-Ray Tomography Data

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Introduction

Ability to image volumetric structure of nano/microscale systems in material science brings a better understanding of the structure-function correlations that can significantly increase their performance in applied fields. In contrast to conventional imaging techniques such as SEM, X-ray ptychography has its advantages in providing reconstructions of higher resolution without requiring sophisticated sample preparation. Proposed approach for direct 3D ptychographic tomography has potentially high robustness as all data is “forced” to be consistent with a unique reconstruction volume. Direct 3D reconstruction can be performed using optimized number of projections and angles, relaxing probe overlap condition and reducing data acquisition time provided by possible 3D fly-scan geometry.

2D Ptychographic Tomography

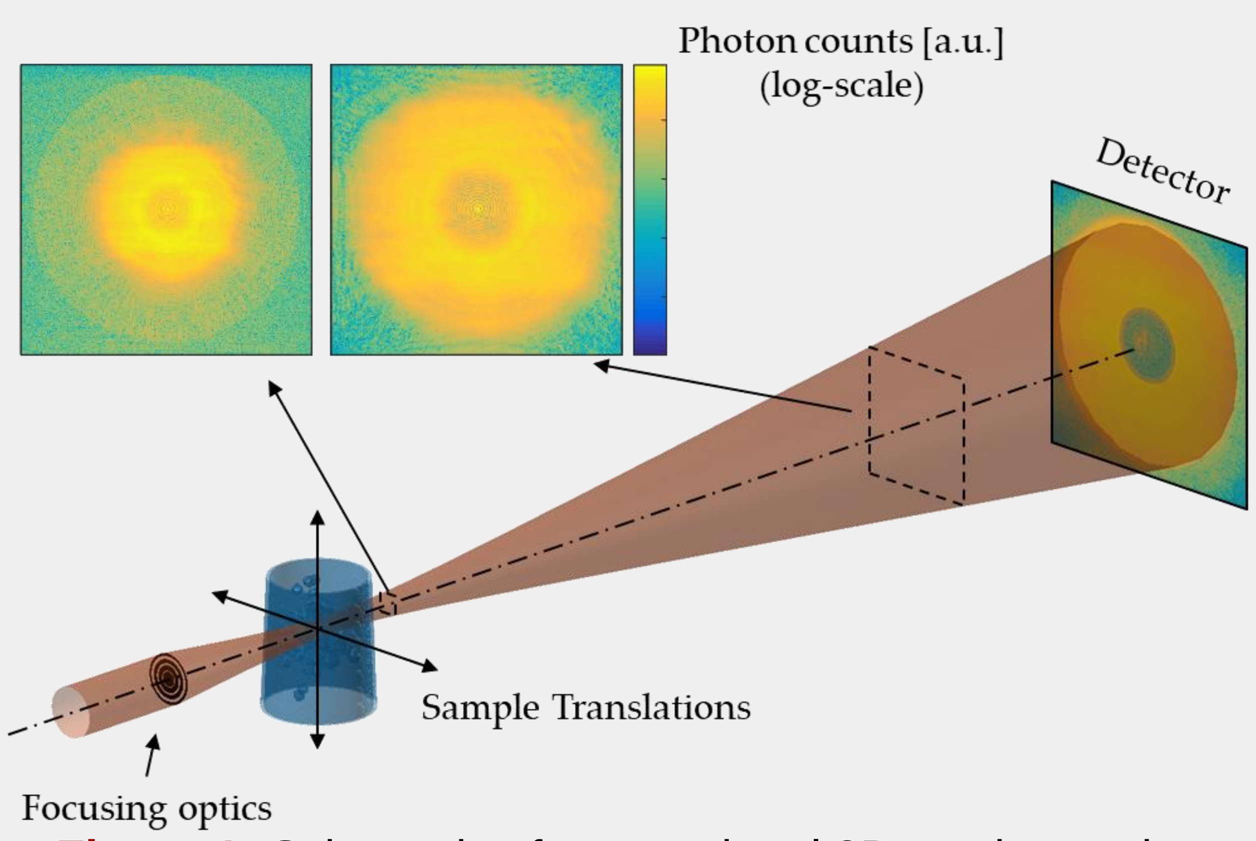
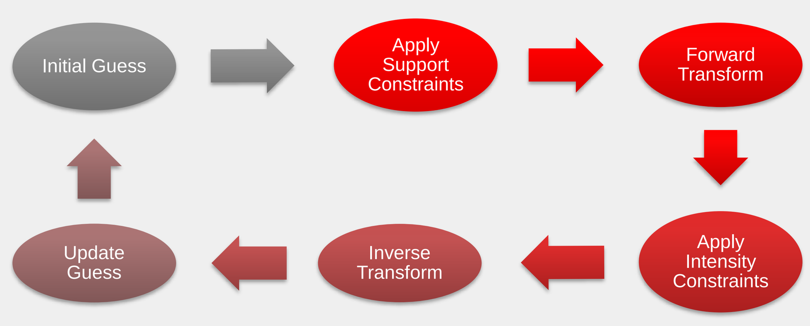
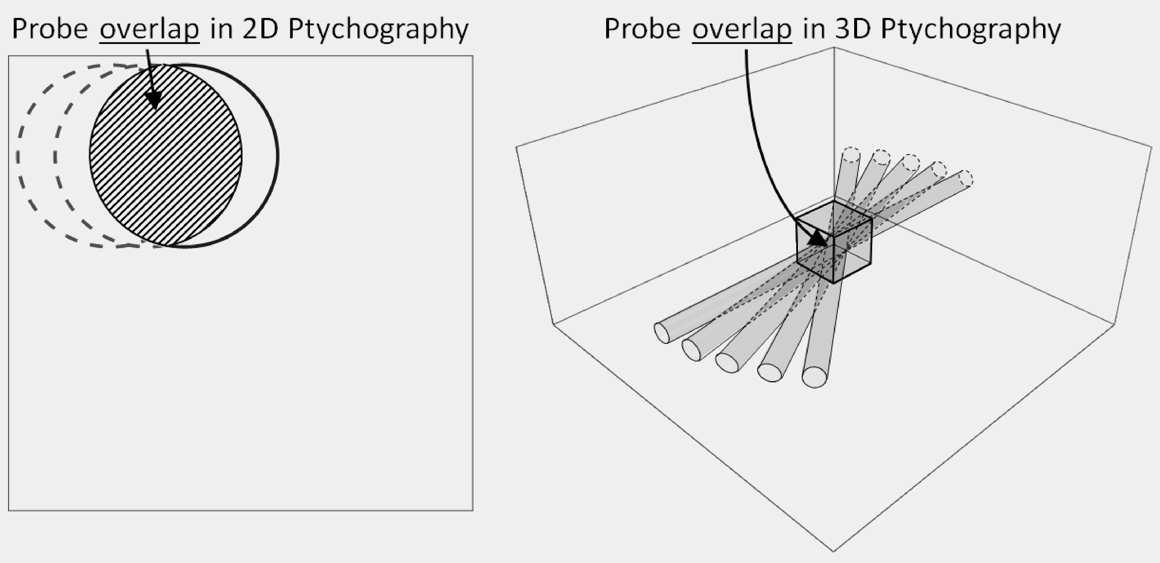


Figure 1: Schematic of conventional 2D ptychography. Reconstruction is performed for each angle independently.

Phase retrieval



Direct 3D Ptychography



Advantages

- Relaxed overlapping conditions
- Reduction in acquired data
- Allows 3D fly-scan
- Faster experiments
- Less radiation damage

Challenges

- Higher memory requirements
- Higher computational costs
- Scanning positions alignment
- Optimal scanning path
- Probe retrieval

Acknowledgments

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Impact of misalignment in scanning positions on reconstruction quality

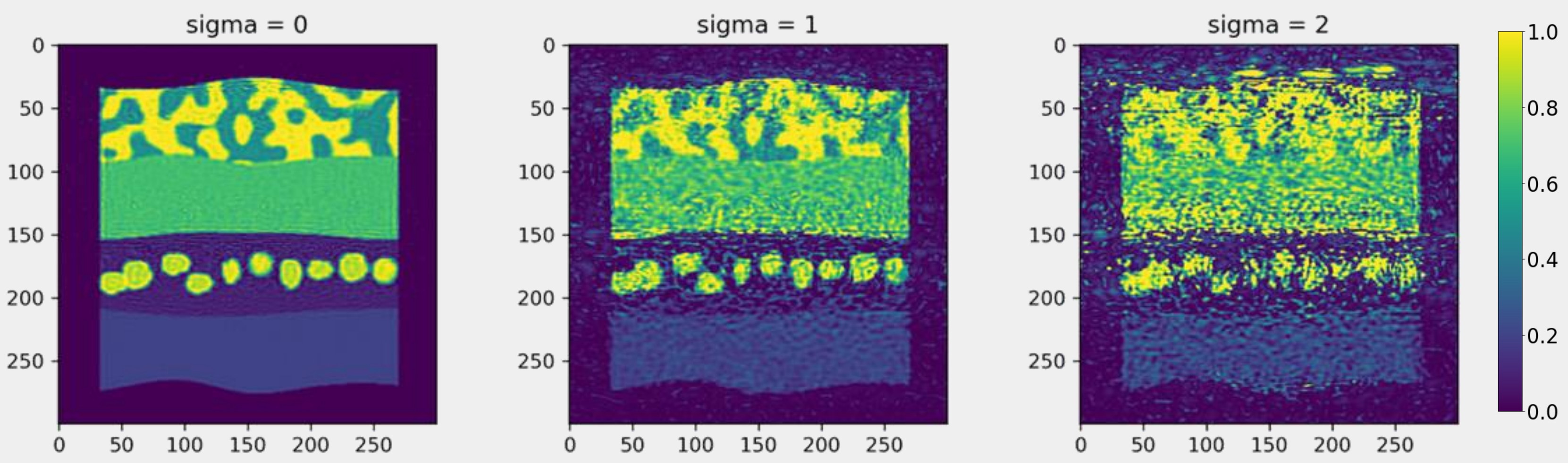

Figure 2: Direct 3D ptychographic reconstructions from full dataset with Gaussian distribution of uncertainties in scanning positions for different values of standard deviation.

Multi-scale reconstruction for fast coarse alignment and better initial guess

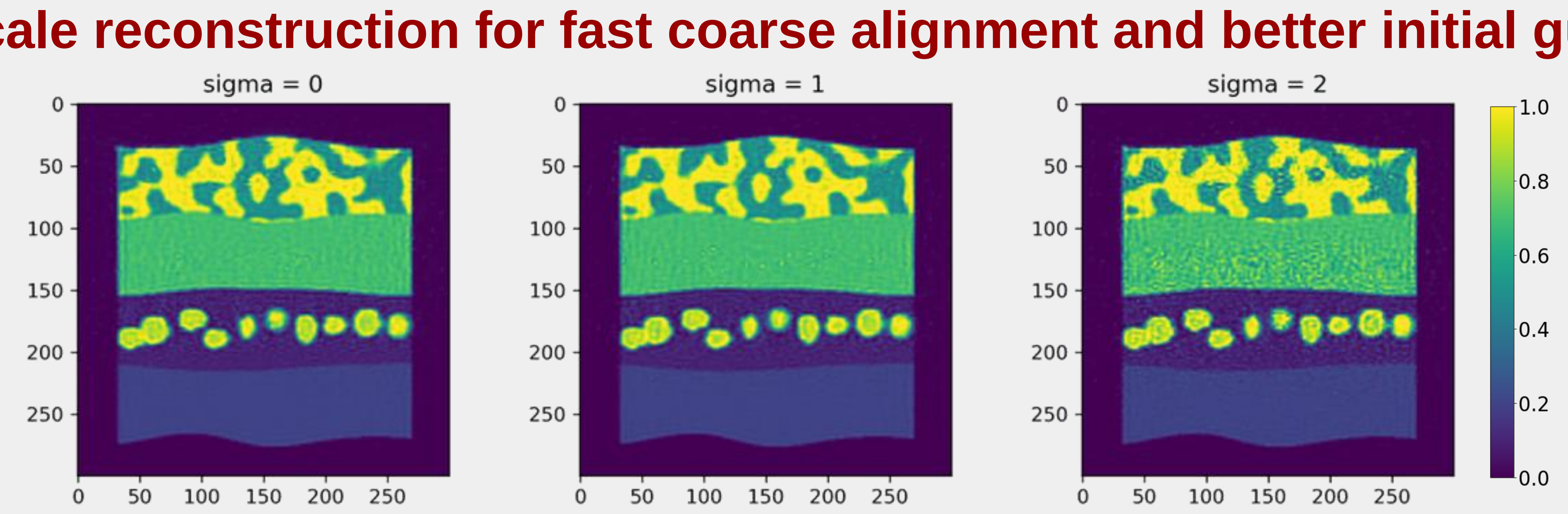

Figure 3: Direct 3D ptychographic reconstructions from reduced dataset with Gaussian distribution of uncertainties in scanning positions for different values of standard deviation.

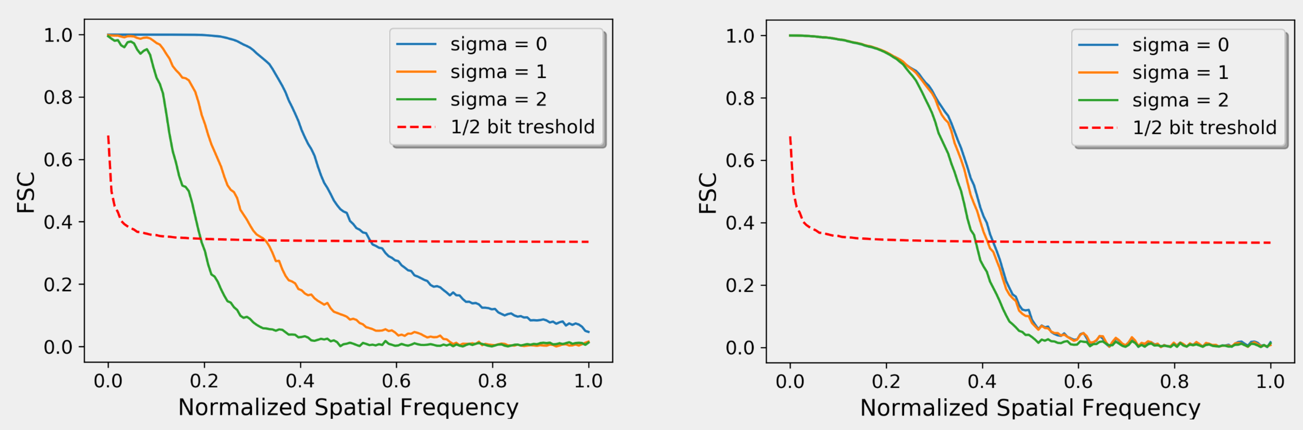

Figure 4: Fourier shell correlation from full (left part) and reduced (right part) datasets reconstruction

Reconstruction of real dataset

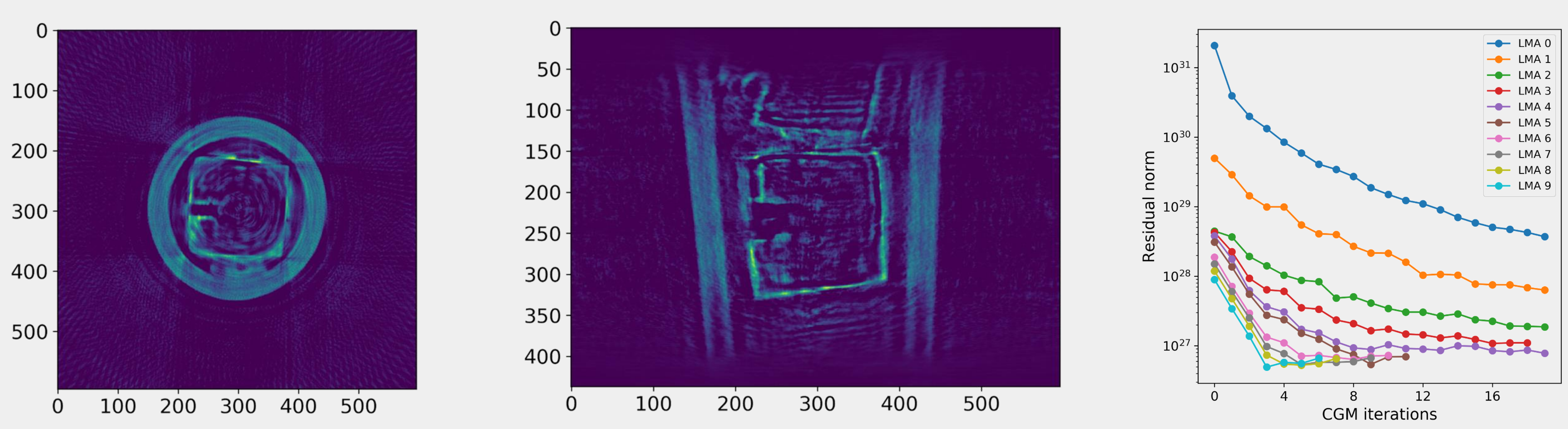

Figure 5: Horizontal and vertical slices of the reconstruction (only real part of complex refractive index is presented). On the right: Residual values over LMA and CGM iterations is shown.

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